# Exhibit A
## SCOPE OF WORK

### TECHNICAL TASK LIST

| Task # | CPR | Task Name |
|---|---|---|
| 1 | N/A | Administration |
| 2 | | Determine Carbon Density of Standing Dead Trees in California's Conifer Forests |
| 3 | | Estimate GHG Emissions and Removals from Standing Dead Trees in California's Conifer Forests |
| 4 | | Incorporate Projections of Dead Tree Carbon Dynamics into GHG Forest Sector Inventory Being Developed for the Air Resources Board |
| 5 | | Evaluate the Capacity of Geospatially Explicit Land Use/Land Cover Databases and Forest Inventory and Assessment Data to Detect and Track Episodes of Catastrophic Tree Mortality |

### KEY NAME LIST

| Task # | Key Personnel | Key Subcontractor(s) | Key Partner(s) |
|---|---|---|---|
| 1 | John Battles | | |
| 2 | John Battles<br>Stella Cousins | | |
| 3 | John Battles<br>Stella Cousins<br>John Sanders | | |
| 4 | John Battles<br>Stella Cousins | | Dr. Patrick Gonzalez (co-Principle Investigator GHG forest sector inventory for ARB, NPS)<br>Dr. Tim Robards (senior personnel, GHG forest sector inventory for ARB, Spatial Informatics Group) |
| 5 | John Battles<br>Stella Cousins | | Dr. Patrick Gonzalez |

**GLOSSARY**
Specific terms and acronyms used throughout this work statement are defined as follows:

| Acronym | Definition |
|---|---|
| ARB | Air Resources Board |
| Energy Commission | California Energy Commission |
| CPR | Critical Project Review |
| FIA | Forest Inventory and Analysis Program |
| GHG | Greenhouse Gas |
| IPCC | Intergovernmental Panel on Climate Change |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| NASA | National Aeronautics and Space Administration |
| NPS | National Park Service |
| PAC | Project Advisory Committee |
| PIER | Public Interest Energy Research |
| UCC.1 | Uniform Commercial Code (Financing Statement) |
| USDA | United States Department of Agriculture |
| USGS | United States Geological Survey |

**Problem Statement**

The Air Resources Board's (ARB) greenhouse gas (GHG) inventory for the forest sector is currently based on a California Energy Commission (Energy Commission) research project which focused on a 1994 to 2000 time interval and a region of northern California. While the project developed estimates of carbon dioxide ($CO_2$) uptake and GHG emissions for forest, range, and other lands, technology transfer of a method for repeated GHG inventory generation and improvement was beyond the scope of work. In addition, this work did not include estimates of emissions from disturbances other than wildfire (e.g., insect outbreaks, disease irruptions, chronic air pollution) that have the potential to cause landscape-scale tree mortality.

These disturbances have become an increasing threat to forest carbon stocks. For example, in California conifer forests between 2008 and 2009, there was a tenfold increase in white fir mortality due to the fir engraver beetle and a 200-300% increase in pine tree deaths due to bark beetles. More worrisome is the fact that in comparable forests in the western United States and Canada, unprecedented outbreaks of bark beetles have decimated millions of hectares of forests. Infested forests have been found to have a 50% reduction in transpiration rates per tree, assimilate 63% less methane ($CH_4$), and produce 133% more nitrous oxide ($N_2O$). Prolonged local increases in GHG emissions are highly likely to transform impacted forest ecosystems from effective sinks to sources of atmospheric carbon (C) and nitrogen (N) GHG compounds. Nor are insect outbreaks the only potential cause of landscape-scale tree mortality. Introduced diseases (e.g., white pine blister rust, pitch canker, sudden oak death) can cause

epidemic mortality in susceptible species. And in many instances, chronic air pollution (e.g., ozone and nitrogen deposition) acts as a synergistic stressor on tree health. For example the number of standing dead sugar pine trees in Sequoia-Kings Canyon National Parks (29% of live stems) is four times greater than average for this species in California (7% of live stems, Forest Inventory and Assessment). The cause of the increased mortality is thought to be the combined effects of white pine blister rust, an exotic fungal pathogen, and exposure to high levels of ozone and nitrogen pollution. Whatever the cause, the end result is a large fraction of standing dead trees on the forest landscape.

An estimate of the GHG emissions due to current and predicted disturbances capable of causing landscape-scale tree mortality in California is lacking. The demography of these dead trees and their decomposition rate are unknowns. Because they remain standing, they are not counted in the deadwood carbon pool yet they are net emitters of $CO_2$ as they decompose “on the stump.” This important problem needs to be addressed in order to project regional-level ecosystem GHG budgets. These types of budgets are necessary to predict the capacity of California forests to store and sequester carbon and provide offsets for utility operators.

**Goals of this Agreement**

The goals of this Agreement are to:

- Develop a remote-sensing based method to quantify the potential of California forests to generate offsets for energy producers in the form of sequestered carbon, thereby reducing the costs for energy consumers.
- Estimate the GHG emissions associated with invasive forest pests using the remote-sensing based method.

**Objectives of this Agreement**

The new GHG inventory method developed as part of this Agreement will be data-driven with the primary monitoring data being remotely sensed information. The satellite imagery provides both wall-to-wall spatial coverage and year-to-year temporal coverage. The researchers will use biometric data (field inventories) to interpret and categorize the remotely sensed images. The developed inventory method will have robust estimates of uncertainty and conform (at a minimum) to accepted international standards of the Intergovernmental Panel on Climate Change (IPCC) in terms of carbon/GHG accounting.

The effort will result in a revised estimate of carbon stocks available in the forest sector. It will also determine GHG emissions associated with catastrophic tree mortality, which is necessary for accurate accounting. This will be used to develop an improved method to determine potential carbon off-sets for the energy sectors.

These objectives will be accomplished by:

- Designing an operational method to repeat estimates of vegetation carbon density for the forest sector in California for 2005 and 2010 that accounts for the carbon stored in standing dead trees;
- Estimating GHG emissions and removals due to catastrophic tree mortality unrelated to wildfire in California for 2005 and 2010; and
- Exploring operational methods to monitor and track landscape-scale tree mortality in California's forests.

## TASK 1.0 ADMINISTRATION

## MEETINGS

### Task 1.1 Attend Kick-off Meeting

The goal of this task is to establish the lines of communication and procedures for implementing this Agreement.

**The Contractor shall:**

- Attend a "kick-off" meeting with the Commission Contract Manager, the Contracts Officer, and a representative of the Accounting Office. The Contractor shall bring their Project Manager, Contracts Administrator, Accounting Officer, and others designated by the Commission Contract Manager to this meeting. The administrative and technical aspects of this Agreement will be discussed at the meeting. Prior to the kick-off meeting, the Commission Contract Manager will provide an agenda to all potential meeting participants.

  The administrative portion of the meeting shall include, but not be limited to, the following:
  - Terms and conditions of the Agreement
  - CPRs (Task 1.2)
  - Match fund documentation (Task 1.7)
  - Permit documentation (Task 1.8)

  The technical portion of the meeting shall include, but not be limited to, the following:
  - The Commission Contract Manager's expectations for accomplishing tasks described in the Scope of Work;
  - An updated Schedule of Deliverables
  - Progress Reports (Task 1.4)
  - Technical Deliverables (Task 1.5)
  - Final Report (Task 1.6)

The Commission Contract Manager shall designate the date and location of this meeting.

**Contractor Deliverables:**

- An Updated Schedule of Deliverables

- An Updated Gantt Chart (if included)
- An Updated List of Match Funds
- An Updated List of Permits

**Commission Contract Manager Deliverables:**
- Final Report Instructions

**Task 1.2 CPR Meetings**
The goal of this task is to determine if the project should continue to receive Energy Commission funding to complete this Agreement and if it should, are there any modifications that need to be made to the tasks, deliverables, schedule or budget.

CPRs provide the opportunity for frank discussions between the Energy Commission and the Contractor. CPRs generally take place at key, predetermined points in the Agreement, as determined by the Commission Contract Manager and as shown in the Technical Task List above and in the Schedule of Deliverables. However, the Commission Contract Manager may schedule additional CPRs as necessary, and, if necessary, the budget will be reallocated to cover the additional costs borne by the Contractor, but the overall contract amount will not increase.

Participants include the Commission Contract Manager and the Contractor, and may include the Commission Contracts Officer, the PIER Program Team Lead, other Energy Commission staff and Management as well as other individuals selected by the Commission Contract Manager to provide support to the Energy Commission.

**The Commission Contract Manager shall:**
- Determine the location, date and time of each CPR meeting with the Contractor. These meetings generally take place at the Energy Commission, but they may take place at another location.

- Send the Contractor the agenda and a list of expected participants in advance of each CPR. If applicable, the agenda shall include a discussion on both match funding and permits.

- Conduct and make a record of each CPR meeting. One of the outcomes of this meeting will be a schedule for providing the written determination described below.

- Determine whether to continue the project, and if continuing, whether or not to modify the tasks, schedule, deliverables and budget for the remainder of the Agreement, including not proceeding with one or more tasks. If the Commission Contract Manager concludes that the project needs a formal amendment or that satisfactory progress is not being made and the project needs to be ended, these conclusions will be referred to the Commission's Research, Development and Demonstration Policy Committee for its concurrence.

- Provide the Contractor with a written determination in accordance with the schedule. The written response may include a requirement for the Contractor to revise one or more deliverable(s) that were included in the CPR.

**The Contractor shall:**

- Prepare a CPR Report for each CPR that discusses the progress of the Agreement toward achieving its goals and objectives. This report shall include recommendations and conclusions regarding continued work of the projects. This report shall be submitted along with any other deliverables identified in this Scope of Work. Submit these documents to the Commission Contract Manager and any other designated reviewers at least 15 working days in advance of each CPR meeting.

- Present the required information at each CPR meeting and participate in a discussion about the Agreement.

**Contractor Deliverables:**

- CPR Report(s)
- CPR deliverables identified in the Scope of Work

**Commission Contract Manager Deliverables:**

- Agenda and a List of Expected Participants
- Schedule for Written Determination
- Written Determination

**Task 1.3 Final Meeting**

The goal of this task is to closeout this Agreement.

**The Contractor shall:**

- Meet with the Energy Commission to present the findings, conclusions, and recommendations. The final meeting must be completed during the closeout of this Agreement.

  This meeting will be attended by, at a minimum, the Contractor, the Commission Contracts Officer, and the Commission Contract Manager. The technical and administrative aspects of Agreement closeout will be discussed at the meeting, which may be two separate meetings at the discretion of the Commission Contract Manager.

  The technical portion of the meeting shall present findings, conclusions, and recommended next steps (if any) for the Agreement. The Commission Contract Manager will determine the appropriate meeting participants.

  The administrative portion of the meeting shall be a discussion with the Commission Contract Manager and the Contracts Officer about the following Agreement closeout items:

- What to do with any state-owned equipment (Options)
- Need to file UCC.1 form re: Energy Commission's interest in patented technology
- Energy Commission's request for specific "generated" data (not already provided in Agreement deliverables)
- Need to document Contractor's disclosure of "subject inventions" developed under the Agreement
- "Surviving" Agreement provisions, such as repayment provisions and confidential deliverables
- Final invoicing and release of retention

- Prepare a schedule for completing the closeout activities for this Agreement.

**Deliverables:**
- Written documentation of meeting agreements and all pertinent information
- Schedule for completing closeout activities

**REPORTING**

**See Exhibit D, Reports/Deliverables/Records.**

**Task 1.4 Quarterly Progress Reports**
The goal of this task is to periodically verify that satisfactory and continued progress is made towards achieving the research objectives of this Agreement.

**The Contractor shall:**
- Prepare progress reports which summarize all Agreement activities conducted by the Contractor for the reporting period, including an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns. Each progress report is due to the Commission Contract Manager within 10 working days after the end of the reporting period. Attachment A-2, Progress Report Format, provides the recommended specifications.

**Deliverables**:
- Quarterly Progress Reports

**Task 1.5 Test Plans, Technical Reports and Interim Deliverables**
The goal of this task is to set forth the general requirements for submitting test plans, technical reports and other interim deliverables, unless described differently in the Technical Tasks. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

**The Contractor shall:**

- Unless otherwise directed in this Scope of Work, submit a draft of each deliverable listed in the Technical Tasks to the Commission Contract Manager for review and comment in accordance with the approved Schedule of Deliverables. The Commission Contract Manager will provide written comments back to the Contractor on the draft deliverable within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final deliverable to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final deliverable within 5 working days of receipt. Key elements from this deliverable shall be included in the Final Report for this project.

**Task 1.6 Final Report**

The goal of this task is to prepare a comprehensive written Final Report that describes the original purpose, approach, results and conclusions of the work done under this Agreement. The Commission Contract Manager will review and approve the Final Report. The Final Report must be completed on or before the termination date of the Agreement. When creating these deliverables, the Contractor shall use and follow, unless otherwise instructed in writing by the Commission Contract Manager, the latest version of the PIER Style Manual published on the Energy Commission's web site:

http://www.energy.ca.gov/contracts/pier/contractors/index.html

The Final Report shall be a public document. If the Contractor has obtained confidential status from the Energy Commission and will be preparing a confidential version of the Final Report as well, the Contractor shall perform the following subtasks for both the public and confidential versions of the Final Report.

**Task 1.6.1 Final Report Outline**

**The Contractor shall:**

- Prepare a draft outline of the Final Report.

- Submit the draft outline of Final Report to the Commission Contract Manager for review and approval. The Commission Contract Manager will provide written comments back to the Contractor on the draft outline within 10 working days of receipt. Once agreement has been reached on the draft, the Contractor shall submit the final outline to the Commission Contract Manager. The Commission Contract Manager shall provide written approval of the final outline within 5 working days of receipt.

**Deliverables:**

- Draft Outline of the Final Report
- Final Outline of the Final Report

**Task 1.6.2 Final Report**

**The Contractor shall:**

- Prepare the draft Final Report for this Agreement in accordance with the approved outline.

- Submit the draft Final Report to the Commission Contract Manager for review and comment. The Commission Contract Manager will provide written comments within 10 working days of receipt.

  Once agreement on the draft Final Report has been reached, the Commission Contract Manager shall forward the electronic version of this report for Energy Commission internal approval. Once the approval is given, the Commission Contract Manager shall provide written approval to the Contractor within 5 working days.

- Submit one bound copy of the Final Report with the final invoice.

**Deliverables**:

- Draft Final Report
- Final Report

**MATCH FUNDS, PERMITS, AND ELECTRONIC FILE FORMAT**

**Task 1.7 Identify and Obtain Matching Funds**

The goal of this task is to ensure that the match funds planned for this Agreement are obtained for and applied to this Agreement during the term of this Agreement.

The costs to obtain and document match fund commitments are not reimbursable through this Agreement. While the PIER budget for this task will be zero dollars, the Contractor may utilize match funds for this task. Match funds shall be spent concurrently or in advance of PIER funds during the term of this Agreement. Match funds must be identified in writing, and the associated commitments obtained before the Contractor can incur any costs for which the Contractor will request reimbursement.

**The Contractor shall:**

- Prepare a letter documenting the match funding committed to this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:

  1. If no match funds were part of the proposal that led to the Energy Commission awarding this Agreement and none have been identified at the time this Agreement starts, then state such in the letter.

  2. If match funds were a part of the proposal that led to the Energy Commission

awarding this Agreement, then provide in the letter:

- A list of the match funds that identifies the:
  - Amount of each cash match fund, its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied.

  - Amount of each in-kind contribution, a description, documented market or book value, and its source, including a contact name, address and telephone number and the task(s) to which the match funds will be applied. If the in-kind contribution is equipment or other tangible or real property, the Contractor shall identify its owner and provide a contact name, address and telephone number, and the address where the property is located.

- A copy of the letter of commitment from an authorized representative of each source of cash match funding or in-kind contributions that these funds or contributions have been secured.

- Discuss match funds and the implications to the Agreement if they are significantly reduced or not obtained as committed, at the kick-off meeting. If applicable, match funds will be included as a line item in the progress reports and will be a topic at CPR meetings.

- Provide the appropriate information to the Commission Contract Manager if during the course of the Agreement additional match funds are received.

- Notify the Commission Contract Manager within 10 working days if during the course of the Agreement existing match funds are reduced. Reduction in match funds may trigger an additional CPR.

**Deliverables:**
- A letter regarding Match Funds or stating that no Match Funds are provided
- Letter(s) for New Match Funds
- A copy of each Match Fund commitment letter
- Letter that Match Funds were Reduced (if applicable)

**Task 1.8 Identify and Obtain Required Permits**
The goal of this task is to obtain all permits required for work completed under this Agreement in advance of the date they are needed to keep the Agreement schedule on track.

Permit costs and the expenses associated with obtaining permits are reimbursable under this Agreement. Permits must be identified in writing before the Contractor can incur any costs related to the use of the permit(s) for which the Contractor will request reimbursement.

**The Contractor shall:**

- Prepare a letter documenting the permits required to conduct this Agreement and submit it to the Commission Contract Manager at least 2 working days prior to the kick-off meeting:

    1. If there are no permits required at the start of this Agreement, then state such in the letter.

    2. If it is known at the beginning of the Agreement that permits will be required during the course of the Agreement, provide in the letter:

        - A list of the permits that identifies the:
            - Type of permit
            - Name, address and telephone number of the permitting jurisdictions or lead agencies
        - Schedule the Contractor will follow in applying for and obtaining these permits.

- The list of permits and the schedule for obtaining them will be discussed at the kick-off meeting, and a timetable for submitting the updated list, schedule and the copies of the permits will be developed. The implications to the Agreement if the permits are not obtained in a timely fashion or are denied will also be discussed. If applicable, permits will be included as a line item in the progress reports and will be a topic at CPR meetings.

- If during the course of the Agreement additional permits become necessary, then provide the appropriate information on each permit and an updated schedule to the Commission Contract Manager.

- As permits are obtained, send a copy of each approved permit to the Commission Contract Manager.

- If during the course of the Agreement permits are not obtained on time or are denied, notify the Commission Contract Manager within 5 working days. Either of these events may trigger an additional CPR.

**Deliverables:**

- A letter documenting the Permits or stating that no Permits are required
- Updated list of Permits as they change during the Term of the Agreement
- Updated schedule for acquiring Permits as it changes during the Term of the Agreement
- A copy of each approved Permit

**Task 1.9 Electronic File Format**
The goal of this task is to unify the formats of electronic data and documents provided to the Energy Commission as contract deliverables. Another goal is to establish the computer platforms, operating systems and software that will be required to review and approve all software deliverables.

**The Contractor shall:**
- Deliver documents to the Commission Contract Manager in the following formats:
  - Data sets shall be in Microsoft (MS) Access or MS Excel file format.
  - PC-based text documents shall be in MS Word file format.
  - Documents intended for public distribution shall be in PDF file format, with the native file format provided as well.
  - Project management documents shall be in MS Project file format.

- Request exemptions to the electronic file format in writing at least 90 days before the deliverable is submitted.

**Deliverables:**
- A letter requesting exemption from the Electronic File Format (if applicable)

**TECHNICAL TASKS**

The Contractor shall prepare all deliverables in accordance with the requirements in Task 1.5. Deliverables not requiring a draft version are indicated by marking "(no draft)" after the deliverable name.

**Task 2 Determine Carbon Density of Standing Dead Trees in California's Conifer Forests**

The goal of this task is to develop transfer functions that estimate the carbon density of standing dead trees for the dominant species in California's conifer forests. The functions will be developed for each species (or species group) and will be a function of time since mortality, tree size, forest structure, and bioclimatic region. Note that the need to know the age (defined as time since death) of standing dead trees limits the sampling to the rare sites that track the fate of standing dead stems.

**The Contractor shall:**
- Measure the carbon density of a representative sample of standing dead trees with a known time since death in: 1) old-growth fir forests in the Southern Sierra Nevada (field site: Yosemite and Sequoia-Kings Canyon National Parks); 2) managed mixed conifer forests in the Central Sierra Nevada (field site: Blodgett Forest Research Station); and 3) managed and reserved (no active management) redwood forests in the Coast Range (field site: Jackson State Demonstration and Research Forest).
- Estimate diameter, taper, height, and standing volume of sampled trees.

- Collect core samples from dead stems to estimate wood density across the bark-to-pith gradient.
- Measure wood and carbon density of core samples.
- Develop species-specific transfer functions using appropriate statistics.
- Prepare a technical memo on species-specific transfer functions that estimate carbon density of standing dead stems.

**Deliverables:**
- Technical memo on species-specific transfer functions (no draft)

### Task 3 Estimate GHG Emissions and Removals from Standing Dead Trees in California's Conifer Forests

The goal of this task is to estimate the carbon dynamics of standing dead trees in order to account for their GHG emissions. To do so, the Contractor will develop the demography of standing dead trees from monitoring data available at the research sites mentioned in Task 2. Basically, the Contractor will need to know how long a standing dead tree remains standing and its decomposition trajectory from a recently dead tree (birth in terms of dead tree demography) to its transition to the surface dead wood pool (death in terms of dead tree demography).

**The Contractor shall:**
- Analyze the demography of standing dead trees for the major conifer species from the available inventory and monitoring data.
- Estimate mean and median longevity of standing dead trees for the major conifer species in Yosemite and Sequoia-Kings Canyon National Parks, Blodgett Forest Research Station, and Jackson State Demonstration and Research Forest.
- Merge the demographic results with the carbon density functions (Task 2) to project decomposition trajectory of standing dead trees.
- Estimate GHG emissions based from standing dead trees based on the decomposition trajectory.
- Prepare a technical memo on projections (by species or major species group) of the GHG emissions for standing dead trees.

**Deliverables:**
- Technical memo on projections (by species or major species group) of the GHG emissions for standing dead trees (no draft)

### Task 4 Incorporate Projections of Dead Tree Carbon Dynamics into GHG Forest Sector Inventory Being Developed for the Air Resources Board

The goal of this task is to refine the forest sector GHG inventory by including the contribution of standing dead trees to the 2005 and 2010 carbon inventory. The ARB GHG inventory project relies on biometric information derived from the Forest Inventory and Analysis (FIA) program to link remotely sensed parameters to carbon density. The Contractor will extend the link to include standing dead trees.

**The Contractor shall:**

- Apply carbon transfer functions to FIA data on standing dead trees (species, diameter) to estimate dead tree carbon pool for the conifer forests in California in 2005.
- Based on 2005 inventory, project GHG emissions from standing dead trees from 2005 to 2010.
- Estimate carbon stored in dead tree pool in 2010.
- Prepare a technical memo on the projected GHG emissions from dead trees from 2005-2010 from California's conifer forests.

**Deliverables:**

- Technical memo on the projected GHG emissions from dead trees from 2005-2010 from California's conifer forests (no draft)

**Task 5 Evaluate the Capacity of Geospatially Explicit Land Use/Land Cover Databases and Forest Inventory and Assessment Data to Detect and Track Episodes of Catastrophic Tree Mortality**

The goal of this task is test the ability of existing remote-sensing imagery (e.g., MODIS Land Cover Type, MODIS Normalized Difference Vegetation Index) along with the FIA data to monitor episodes of landscape level tree mortality. Both of these databases meet the ARB definition of "operational methods", namely that they are routinely maintained by a government agency (e.g., National Aeronautics and Space Administration and the U.S. Department of Agriculture Forest Service) and are periodically updated and validated.

**The Contractor shall:**

- Identify conifer forests in the Sierra Nevada that span a gradient in the fraction of trees that are dead.
- Explore ability of geospatial imagery to detect known gradients in tree mortality.
- Recommend best practices for monitoring tree mortality based on existing databases.
- Prepare a technical memo on the evaluation of existing databases to detect and track episodic tree mortality.

**Deliverables:**

- Technical memo on the evaluation of existing databases to detect and track episodic tree mortality (no draft)